

U. S. ARMY TEST AND EVALUATION COMMAND  
DEVELOPMENT TEST II (ET) - COMMON TEST OPERATIONS PROCEDURES

AMSTE-RP-702-103

\*Test Operations Procedure 4-2-809

1 February 1974

AD 777919

RECOVERY OF FIRED AMMUNITION

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SECTION I  
GENERAL

1. Purpose and Scope. This TOP describes the techniques for soft recovery of fired ammunition that are used at TECOM installations. These techniques can be used to recover mortar, recoilless rifle, tank, field artillery, and antiaircraft artillery ammunition. The recovery of rocket warheads, missiles, and small arms projectiles is not included. The recovery method to be used will depend on the test objective.
2. Background. The object of recovering projectiles after firing is to determine the effects of the dynamic forces of launching, flight, and in some instances, impact on the item and its components. There are a number of methods by which recovery is facilitated, with varying degrees of success. Some entail retrieving the test item after impact in sand, sawdust, water, Celotex, or a prepared field. Other methods available are by means of rocket sled, parachute, long tube utilizing compressed

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air, and water-rail deceleration system. This TOP was prepared as part of a study described in reference 4 (appendix).

3. Equipment and Facilities. Equipment and facilities are indicated in the applicable paragraphs below.

## SECTION II TEST PROCEDURES

4. Preliminary Activities. The test director selects the appropriate recovery method from those described below. Preparations needed are included with each description.

5. Vertical Firing Recovery.

5.1 Objective. To determine the effects of the dynamic forces of launching, flight, and in some instances, impact on the test item and its components.

5.2 Standards. None applicable.

5.3 Method.

5.3.1 Basic Principle. If a rotating projectile is fired vertically or near vertically at 83 to 90 degrees quadrant elevation (QE), it will not track over the summit of its trajectory but will descend base first. When it strikes soft earth base first, the amplitude of shock will be less than was experienced on firing, and little, if any, further damage will be done to the nose fuze or interior components.

5.3.2 Test Facility (Fig. 1).

a. The test facility consists of an area of land not less than 145 acres loosely disced to a depth of 6 or more inches to break up the hard ground surface to soften the impact.

b. The impact field is gridmarked with numerically identified vertical posts that are readily visible from the outlying observation towers.

c. The observation towers are located on, and adjacent to, the recovery field (see TOP/MTP 3-2-825) and have radio or telephone communication with the firing position. They are provided with protective armor.

5.3.3 Weapon Positions and Firing Sites.

a. The weapons are located so that prevailing winds aloft will carry the projectile away from the weapon position and toward the recovery field.

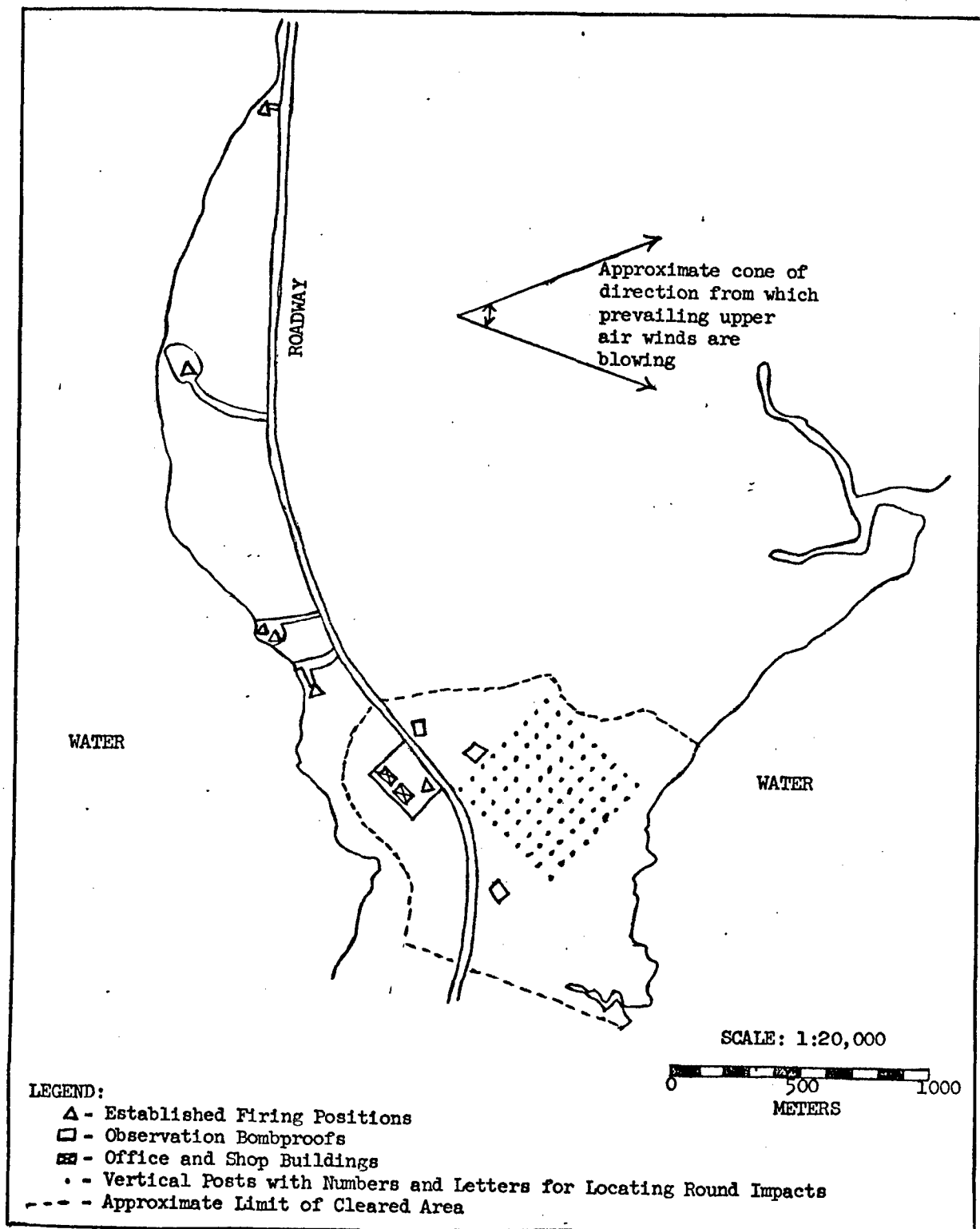


Figure 1. Representative Vertical Recovery Test Facility.

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b. The individual firing sites, if more than one, are offset from each other to prevent possible damage when firing from rear positions.

c. Table 1 shows suggested distances from firing positions to center-of-impact areas and approximate QE's for the firing of various caliber weapons. The elevations must be adequate to insure initial impacts in the recovery area for prevailing upper winds not exceeding 40 miles per hour. Table 1 contains general information suitable for establishing starting points only. Actual values will vary depending on drag characteristics of the type projectile being fired, meteorological data, etc.

Table 1 - Firing Facility Data

Cannon <sup>1</sup>	Muzzle Velocity, mps	Starting Elevations		Distance of Weapon from Impact Area, meters	Maximum Altitude for Wind Data, meters <sup>2</sup>	Flight Time, seconds
		Degrees	Minutes			
105-mm Howitzer M2A1	198	83		500	1,780	38
	216	84		500	2,390	44
	238	85		500	2,835	48
	267	86		500	3,870	56
	312	87		500	4,595	61
	377	88		500	5,880	69
	473	89 to 90		500	8,920	85
155-mm Howitzer M126	274	84		1,400	3,085	50
	316	85	30	1,400	4,155	58
	375	86	30	1,400	5,710	68
	464	87	45	1,400	7,900	80
	564	89		1,400	10,000	90
	684	89 to 90		1,400	11,500	100
8-Inch Howitzer M2A1	250	83	45	1,400	1,425	34
	274	83	30	1,400	1,785	38
	305	85	45	1,400	2,845	48
	351	86		1,400	5,060	64
	422	88	30	2,300	7,510	78
	500	85	30	2,300	9,560	88
	595	87		2,300	12,850	102
155-mm Gun M2A1	640	86		2,300	13,870	106
	853	88		2,300	19,915	127
175-mm Gun M113	915	87		3,000	25,000	146

<sup>1</sup>In most cases cannon may be mounted on several types of mounts; e.g., SP, pedestal, towed.

<sup>2</sup>For purposes of aircraft safety, see discussion in paragraph 5.3.7e.

5.3.4 Weapon Emplacement. The following are examples of weapon emplacement procedures.

a. 105-mm Towed Howitzer. Place the trails of the howitzer in holes approximately 4 feet deep. Raise the front end of the carriage and hold in position by placing a metal stand (36 inches high by 10 inches wide) under the tire of each wheel. Elevate in accordance with table 1.

b. 155-mm Towed Howitzer. Dig the trails into the earth to a depth of about 4 feet. Raise the front end of the carriage to a 35-degree slope and hold in place by inserting hardwood timbers under the front jack plate as in figure 2. Elevate in accordance with table 1.



Figure 2. 155-mm Howitzer in Position for Vertical Firing.

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c. 175-mm SP Gun. Emplace this vehicle on an earth embankment having a 25-degree slope (fig. 3). Elevate in accordance with table 1.



Figure 3. 175-mm Gun in Position for Vertical Firing.

d. 8-Inch Towed Howitzer, 155-mm Towed Gun. Emplace these weapons on an earth embankment having a 35-degree slope. Dig the trails into the earth to a depth of approximately 4 feet (fig. 4). Elevate in accordance with table 1.

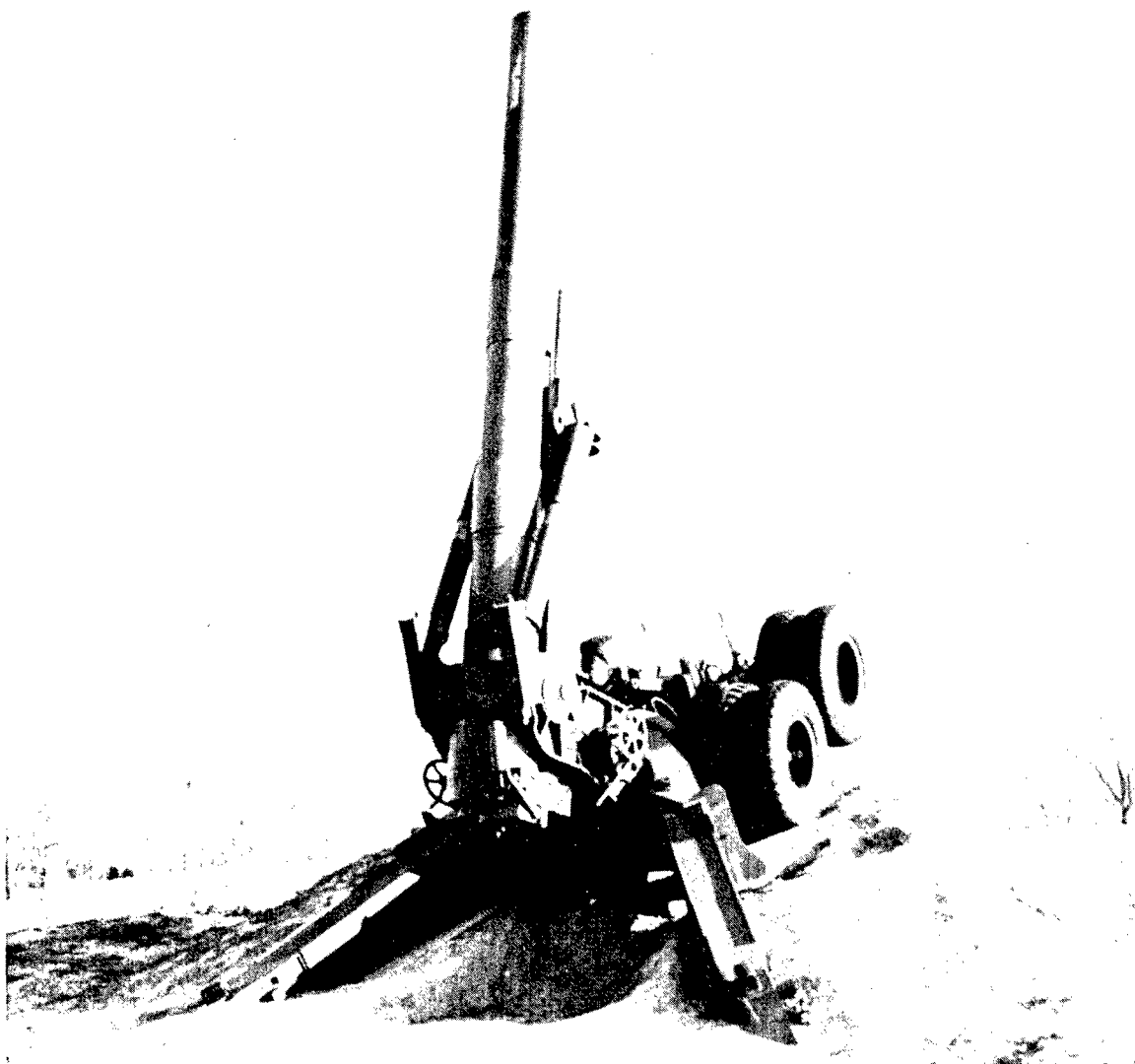


Figure 4. 8-Inch Howitzer in Position for Vertical Firing.

5.3.5 Recoil Mechanism Preparation. The recoil mechanisms of the weapons used in the vertical firing program are pressurized and replenished with oil as indicated in table 2.

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Table 2 - Recoil Pressure and Oil Levels

Weapon	Nitrogen Pressure, psi	Oil Reserve
105-mm Howitzer	1,250	Normal
155-mm Howitzer	1,750	
155-mm Gun	1,920	
8-inch Howitzer	2,100	
175-mm Gun	2,150	

#### 5.3.6 Instrumentation and Equipment.

a. Copper crusher gages, piezoelectric gages, or strain type gages are used to obtain peak or maximum chamber pressures. These values are used to adjust the propelling charge weights to meet the specified acceleration loads. (Pressure gages are described in TOP/MTP 3-2-810, Weapon Pressure Instrumentation.)

b. Mindlin gages are used to measure the peak acceleration loads during setback and deceleration loads when the projectile impacts base first on the field.

c. Radiosonde balloons are used to measure atmospheric conditions.

d. A motor crane equipped with a clamshell bucket is used for recovery. The crane operator's cab is enclosed in armor plate when the field is contaminated or HE projectiles are the test rounds to be recovered.

e. Metal-detecting devices may be used to locate the buried projectiles. To date, the most effective metal-locating device is the Portable Differential Magnetometer (PDM) (reference 3, appendix). The PDM is a lightweight, hand-portable item developed by the Army Land War Laboratory. It has proven capable of locating vertically buried 57-mm projectiles at 7 feet and 175-mm projectiles at 15 feet. For projectiles buried at greater depths, the PDM can be used inside of partially dug holes.

f. Any additional instrumentation and equipment requirements will be ascertained from the specific ammunition test objective.

5.3.7 Range Safety.

a. The upper air wind data, obtained as explained in 5.3.8 below, are considered. Table 1 does not include the effects of ballistic wind. It does, however, provide starting data for weapon aiming that should be adequate when the upper air winds are less than 40 miles per hour. When upper air winds exceed 40 miles per hour or differ considerably from "prevailing" direction, cancellation of firings for that day may be advisable to avoid the danger of impacts too far from the desired impact point.

b. The test director reviews any safety statement on the test item to identify safety limitations required.

c. All applicable SOP's are followed.

d. Communication between firing site, impact area, and any other area involved in the test is verified.

e. Clearances for commercial aircraft must be provided to the Federal Aviation Agency, based upon maximum ordinates and safety factors of TOP 4-1-006 (when issued).

5.3.8 Firing.a. Computing Weapon Elevation and Azimuth.

(1) Using the data of table 1, compute the "starting" (initial) weapon QE,  $\phi_1$ , required to obtain impact at the desired down-range distance,  $X_0$ , in the weapon initial direction (azimuth) of fire,  $\theta_1$ . (It is considered good practice to avoid QE's greater than shown in table 1.) Use this QE for firing a "ranging" round ((2) below) if the upper air winds to maximum ordinate do not exceed 40 miles per hour; if they exceed 40 miles per hour, it may be desirable to correct the above aiming direction for the effect of the corresponding ballistic wind as described in b below. Azimuth is always corrected for wind.

(2) Fire the first ranging round and determine  $X_1$ , the observed range; and  $Y_1$ , the observed deflection from point  $Y_0$  at the desired impact location on the recovery field.

(3) If  $X_1$  differs from  $X_0$  objectionably, calculate an improved elevation angle,  $\phi_2$ , by the following equation:

$$\phi_2 = \phi_1 \left( \frac{X_0 - X_1}{X_0} \right) (90^\circ - \phi_1)$$

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(4) If the gun azimuth of the first round,  $\theta_1$ , resulted in a deflection  $Y_1$  from the desired point on the recovery field, determine a new gun azimuth  $\theta_2$  based upon the conventional correction of 1 mil equals a change of 1 meter at 1,000 meters.

(5) Fire a second ranging round using the new elevation angle  $\phi_2$  and the new azimuth  $\theta_2$ .

(6) If the second ranging round impacts at a range  $X_2$  which differs more than 5% from  $X_0$ , calculate an improved gun elevation  $\phi_3$  by using the formula below.

$$\phi_3 = \phi_1 (X_0 - X_2) / \frac{\Delta X}{\Delta \phi}$$

where

$$\frac{\Delta X}{\Delta \phi} = \frac{\text{change in range per degree}}{\text{change in elevation, derived from the results of (3) above.}}$$

If a further change in azimuth is also needed, repeat the procedure of (4) above.

(7) If necessary, repeat steps (5) and (6) until a gun elevation and azimuth are obtained that result in an impact within a satisfactory distance (never over 5%) from the intended impact point.

NOTE: The  $\Delta X / \Delta \phi$  that is obtained should be retained for future uses in connection with the particular projectile and charge.

b. Ballistic Wind Correction. The atmosphere is "sounded" by radiosonde balloon as near as practicable to the time of firing but never more than 3 hours before the weapon is fired. The ballistic wind is computed from the data as follows:

(1) Resolve the ballistic wind data into range and deflection components and multiply the components by the unit effect of a 1 mph ballistic wind to obtain the predicted range and deflection effects (ref. 5, appendix).

(2) Compute the compensation for the predicted "range" effect of nonstandard ballistic winds by means of the equation in a(3) above.

(3) Make allowance for the predicted "deflection" effect of the nonstandard ballistic wind by tilting the weapon tube to the right or left of  $A_g$ , the azimuthal direction (i.e.,  $A \pm 90^\circ$ ). This is accomplished using the weapon mount traversing mechanism and is possible because (a) the tube elevation is almost 90 degrees and (b) the plane of the standard traversing motion is inclined upward from its normal horizontal position. Final elevation adjustments are made by the trial and error method (a(4) through (6) above).

NOTES: 1. Other details, such as zoning of the atmosphere, are governed by the specific problem at hand. (See ref. 5, appendix.)

2. In the computation of ballistic winds and unit effects, range and deflection are approximately synonymous at elevations near 90°.

5.3.9 Projectile Observation and Recovery. With a gridded field, projectile locations may be observed through a transit from a bombproof tower (or two, where experience indicates). (See TOP/MTP 3-2-825 for techniques for pinpointing impacts.) Recovery is accomplished with a metal detector (para 5.3.6e) and a motor crane equipped with a bucket since excavating to a depth of 30 feet or more is often required. If the field has live duds, or if the test rounds contain explosives, the crane operator's cab is inclosed in armor plate.

5.4 Data Required. The data required are determined by the objective of the test firings. All pertinent measurements, computations, observations, and related data will be reported.

## 6. Long-Range Firing Into Prepared Field.

6.1 Objective. To determine the effects of the dynamic forces of launching, flight, and in some instances, impact on the test item and its components.

6.2 Standards. None applicable.

### 6.3 Method.

6.3.1 Basic Principle. Projectiles fired into a prepared field are fired to impact nose first. They can usually be recovered with little or no damage. The softer the soil of the recovery field, the lower the deceleration forces the projectiles will experience on impact.

### 6.3.2 Test Facility.

a. The test facility consists of an area of land large enough to accommodate any projectile dispersion. The field should be clear of any grass, trees, or rocks that may inhibit projectile impacts or recovery. The soil should be as soft as possible.

b. The observation towers or bombproofs are located on, and adjacent to, each end of the recovery field and have radio or telephone communication with the firing position.

6.3.3 Weapon Location. The weapon is located so that the projectile impact angle into the recovery field is greater than 30 degrees. Any angle less than 30 degrees results in a greater probability that the projectile will ricochet or enter and deflect out of the recovery field.

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#### 6.3.4 Instrumentation and Equipment.

- a. Copper crusher gages, piezoelectric gages, or strain type gages are used to measure peak or maximum chamber pressures.
- b. Two transits are used to determine the exact location of impact of the test item as described in TOP/MTP 3-2-825.
- c. Metal detectors as described in paragraph 5.3.6e are used to detect buried projectiles. Any additional instrumentation and equipment requirements will be ascertained from the specific ammunition test objective.

#### 6.3.5 Range Safety.

- a. The test director reviews any safety statement on the test item to identify safety limitations required.
- b. All applicable SOP's are followed.
- c. Communication between firing site, impact area, and any other area involved in the test is verified.

#### 6.3.6 Firing.

- a. Using firing tables, determine the starting weapon QE required to obtain impact at the desired downrange distance. This elevation will be used to fire the first ranging round.
- b. Fire a ranging round along a line of fire (azimuth) that will give an impact on the extreme edge of the recovery field opposite the side on which the observation towers are located. Determine the observed range  $X_1$ , and the observed deflection  $X_2$ .
- c. Using firing tables, calculate an improved elevation angle if the observed range differs objectionally from the desired range. To determine a new line of fire take the difference between the desired impact point and the observed impact point (change in deflection  $\Delta D$ ) and use the following equation:

$$\Delta M = \frac{\Delta D}{R}$$

where

 $\Delta M$  = change in mils of the line of fire $\Delta D$  = change in deflection (in meters)

$$R = \frac{1}{1000} \times \text{range (in meters)}$$

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NOTES: 1. The desired impact point will be a region on the recovery field most desirable for recovery of the test item.

2. Ranging rounds will be inert rounds with dummy fuzes or inert rounds with supplementary charges and live fuzes.

d. Fire a second ranging round using the new elevation angle and new line of fire.

e. If the impact area of the ranging round is still incorrect, make the necessary changes as in c above.

f. Repeat steps d and e until a weapon elevation and line of fire are established that will result in an impact in the desired impact area.

g. Fire the test rounds along the established elevation and line of fire.

h. Record the location of impact of the test items by one of the following methods:

(1) Each observation point is equipped with a transit. The angle of impact with respect to each observation point is recorded. The intersection of two lines drawn through the observation points at the angle of impact will give the location of impact. (See TOP/MTP 3-2-825 for details on locating impact positions.)

(2) After several rounds are fired, the impact points are marked by use of wooden stakes.

6.3.7 Projectile Recovery. Recovery is accomplished with a motor crane equipped with a clamshell bucket, and a metal detector (para 5.3.6e). If the field has live duds, or if the test rounds contain explosives, the crane operator's cab is inclosed in armor plate.

6.4 Data Required. The data required are determined by the objective of the test firings. All pertinent measurements, computations, observations, and related data will be reported.

## 7. Long-Range Firing Into Water.

7.1 Objective. To determine the effects of the dynamic forces of launching, flight, and in some instances, impact on major caliber inert projectiles and their components.

7.2 Standards. None applicable.

7.3 Method.

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7.3.1 Basic Principle. Projectiles fired into water can usually be recovered with little or no damage incurred. Water is a relatively soft impact medium that will give lower impact deceleration forces than most soils.

7.3.2 Test Facility.

a. The test facility consists of a body of water with an area large enough to accommodate any projectile dispersion. The depth of the water shall be a minimum of 15 feet. A sandy bottom is preferable although not mandatory.

b. The observation towers are located adjacent to the recovery area and have radio or telephone communication with the firing position. There will be three observation towers (see TOP/MTP 3-2-825) since impact location is more critical in this type of recovery.

7.3.3 Weapon Location. The weapon is located so that the projectile impact angle is greater than 15 degrees. Any angle less than 15 degrees results in a greater probability that the projectile will ricochet.

7.3.4 Instrumentation and Equipment.

a. Copper crusher gages, piezoelectric gages, or strain type gages are used to measure peak or maximum chamber pressures.

b. Three transits are used to determine the exact location of impact of the test item.

c. Any additional instrumentation and equipment requirements will be ascertained from the specific ammunition test objective.

7.3.5 Range Safety.

a. The test director reviews any safety statement on the test item to identify safety limitations required. All applicable SOP's are followed.

b. Water recovery is limited to inert projectiles for safety reasons.

c. Communication between firing site, impact area, and any other area involved in the test is verified.

7.3.6 Firing. The firing procedure is the same as in paragraph 6.3.6, long-range firing into prepared field, except for the recording of impact locations (6.3.6h). For water-impact firing three transits are used. The angle of impact with respect to each observation point is recorded, and the intersection of three lines drawn through the observation points at the angle of impact will give the location of impact, as detailed in TOP/MTP 3-2-825.

7.3.7 Projectile Recovery. Two boats (one large and one small) are used in conjunction with two divers for projectile recovery. A buoy is placed at the determined impact point and a 50-foot-radius search pattern is conducted from the buoy to locate the projectile. When found, the projectile is secured with a rope and raised out of the water with the winch located on the large boat. For safety, the divers work in pairs and from the small boat.

7.4 Data Required. The data required are determined by the objective of the test firings. All pertinent measurements, computations, observations, and related data will be reported.

## 8. Point-Blank Firing Into Sawdust, Sand, or Celotex.

8.1 Objective. To determine the effects of the dynamic forces of launching, flight, and in some instances, impact on the test item and its components.

8.2 Standards. The medium must be soft enough not to damage the projectile but resistant enough not to require an excessively long facility.

### 8.3 Method.

8.3.1 Basic Principle. Sawdust, sand, and Celotex are examples of mediums that provide relatively low deceleration forces on projectiles. The maximum projectile velocities allowed using these mediums range up to 3,000 fps for sawdust and Celotex and 1,000 fps for sand, with sawdust the preferred medium. A dry medium is required due to the increased deceleration when the medium is wet and compacted. In all cases a considerable amount of material is needed to stop the projectiles. Celotex can also be used in conjunction with sawdust.

#### 8.3.2 Test Facility.

a. Sawdust. A representative sawdust recovery facility consists of a sawdust-filled wooden box, 12 feet wide by 12 feet high by 118 feet long, lined with 2-1/2-inch steel plate. A hole is located in the front surface of the box into which the projectile is fired. Sectional metal roof covers keep the sawdust dry and allow access into the box for recovery of the projectiles. Wooden screens can be placed at intervals to bracket the location of each round.

b. Sand. A representative sand recovery facility consists of a sand-filled concrete inclosure 17 feet by 17 feet by 60 feet long. The front of the inclosure is open with 3-inch armor plate for the roof. The projectile is fired through the open front and into the sand.

c. Celotex. The Celotex recovery facility consists of 4-foot by 8-foot by 1/2-inch Celotex sheets bundled together and stacked side by side and end to end. A 2-foot spacing is left between the bundles lengthwise to help bracket the location of the projectile. The stacks increase sequentially in size to compensate for any projectile dispersion while traveling through the Celotex. A representative example is shown in figure 5 which indicates the amount of Celotex required to stop a 280-mm projectile with a velocity of 3,000 fps.

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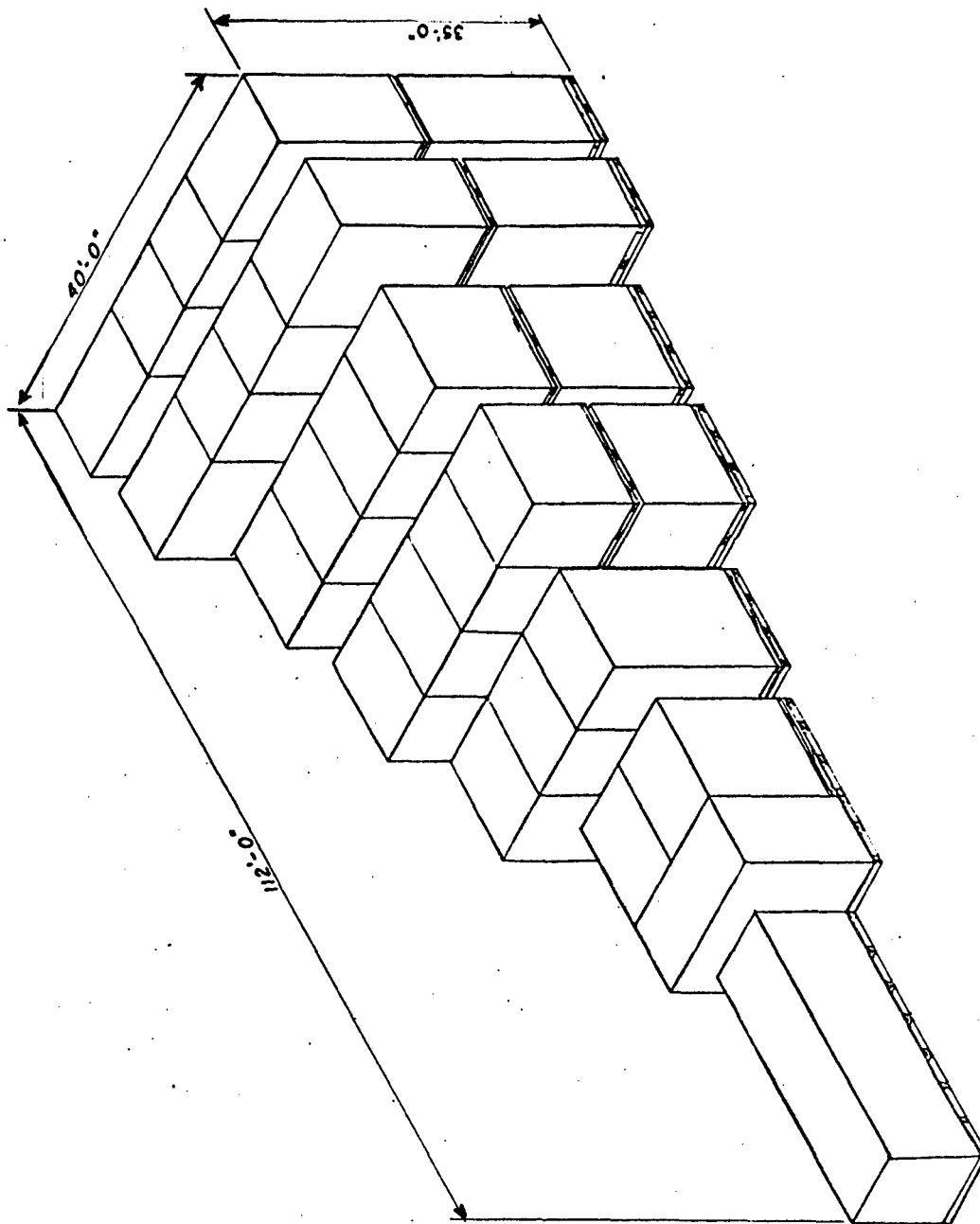


Figure 5. Representative Example of Celotex Recovery Medium.

d. General. Table 3 contains a listing of lengths of sawdust, sand, and Celotex recovery mediums that are suitable for recovering typical mortar projectiles; penetrations for other projectiles will have to be determined on a case-by-case basis.

Table 3 - Calculated Decelerations and Depths of Penetration in Sawdust, Sand, and Celotex for Representative Mortar Ammunition

Caliber	Basic Proj Model	Proj Weight, lb.	Impact Velocity		Deceleration, g			Penetration					
								Sawdust		Sand		Celotex	
			fps	mps	Sawdust	Sand	Celotex	ft	m	ft	m	ft	m
60-mm	M49A4	3.10	520	158.5	388	8,239	550	11	3.35	0.5	0.15	8	2.44
81-mm	M374	9.12	850	259.1	512	13,628	665	22	6.71	0.8	0.24	17	5.18
4.2-Inch	M329	26.23	980	298.7	404	92,460	512	37	11.28	1.4	0.43	29	8.84

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### 8.3.3 Weapon Location.

a. The weapon is located in front of the recovery box a distance substantial enough to accommodate any instrumentation required for the test. The QE must be sufficient to permit the impacts to occur on the recovery boxes.

b. When mortars are fired, the baseplate is mounted in a near-vertical position. A trigger-mounted mortar tube must be used along with a trombone-type fixture for pushing the rounds down the horizontal barrel and seating them gently at the base. The trombone-type fixture is a safety device that permits the loader to be offset from the barrel in the event of premature ignition of the propellant. (It is used only in connection with a trigger-fired mortar and even then only when the projectile cannot be seated by gravity.)

### 8.3.4 Instrumentation and Equipment.

a. Copper crusher gages or piezoelectric gages are used to measure peak or maximum chamber pressures.

b. A motor crane equipped with a bucket or tongs for recovery is required when sawdust or Celotex is used.

c. A shovel is used to recover rounds in sand.

d. A trombone-type fixture (fig. 6) is required for seating the rounds when mortars are fired. This device provides safety to the loader by permitting him to be to the side of the mortar.

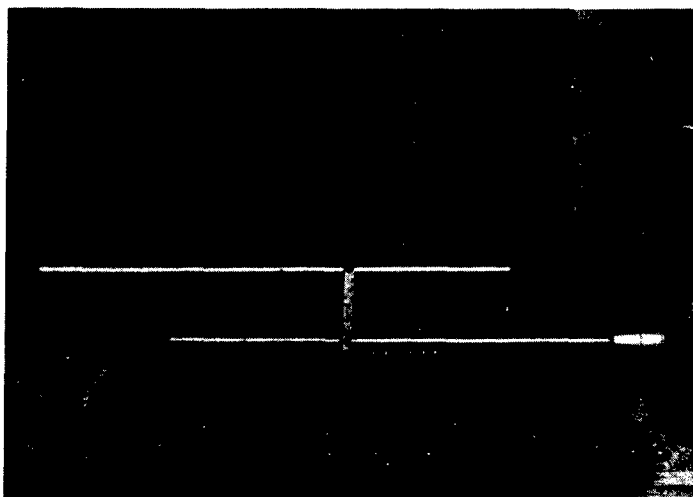


Figure 6. Trombone-Type Fixture for Seating Mortar Rounds.

e. Any additional instrumentation and equipment requirements will be ascertained from the specific ammunition test objective.

#### 8.3.5 Range Safety.

a. The test director reviews any safety statement on the test item to identify safety limitations required.

b. All applicable SOP's are followed.

c. Communication between firing site, impact area, and any other area involved in the test is verified.

d. Fire equipment will be at the firing site in case of fire when sawdust or Celotex is used.

e. The gun is positioned a safe distance from the sawdust or Celotex to prevent muzzle blast from igniting the recovery medium.

f. Rounds fired are restricted to inert-filled projectiles.

g. Any rounds that could initiate a fire while traveling through the medium (for example, tracer rounds) will not be fired into sawdust or Celotex.

8.3.6 Firing. The QE must be sufficient to permit the impacts to occur on the recovery box. Several rounds can be fired into the box before recovery is necessary.

#### 8.3.7 Projectile Recovery.

a. Sawdust or Celotex - Removal of the projectiles is accomplished with a motor crane equipped with tongs.

b. Sand - Access to the projectiles is from the front of the box, and recovery is by digging into the sand.

8.4 Data Required. The data required are determined by the objective of the test firings. All pertinent measurements, computations, observations, and related data will be reported.

### 9. Low Velocity Recovery Firing Using Cloth Target.

9.1 Objective. To determine the effects of the dynamic forces of launching, flight, and in some instances, impact on the test item and its components.

9.2 Standards. None applicable.

9.3 Method.

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9.3.1 Basic Principle. A cloth target is suspended at a suitable distance from the weapon muzzle. Low velocity mortar projectiles are fired at a maximum velocity of 380 fps into this target. The projectile is caught by the target and falls to the ground. The method is explained in detail in reference 2 (appendix).

9.3.2 Test Facility. A cloth "blanket" is suspended on a cord between two poles, typically 150 feet from the weapon muzzle. A representative target is a blanket composed of six (to 20) layers of nylon cloth. The cloth is duck, lightweight, with 2 by 2 basket weave (MIL-C-12369E) and is cut and sewed into 8- by 8-foot layers.

9.3.3 Weapon Requirements.

a. The QE of the weapon must be sufficient to permit the impact to occur on the target.

b. When mortars are fired, a trigger-mounted mortar tube must be used along with a trombone-type fixture for pushing the round down the barrel and seating it at the base of the mortar (para 8.3.3).

9.3.4 Instrumentation and Equipment.

a. Copper crusher gages are used to measure chamber pressure.

b. A trombone-type fixture is required when mortars are fired (9.3.3b above).

c. Any additional instrumentation and equipment requirements will be ascertained from the specific ammunition test objective.

9.3.5 Range Safety.

a. The test director reviews any safety statement on the test item to identify safety limitations required.

b. All applicable SOP's are followed.

c. Communication between firing site, impact area, and any other area included in the test is verified.

9.3.6 Firing. The QE must be sufficient to permit the impact to occur on the cloth target.

9.3.7 Projectile Recovery. The projectile falls to the ground after impact with the cloth target. Projectiles are then picked up by hand.

9.4 Data Required. The data required are determined by the objective of the test firings. All pertinent measurements, computations, observations, and related data will be reported.

## 10. Other Types of Projectile Recovery Techniques.

10.1 Rocket Sled Recovery. A box filled with light-density recovery materials is mounted on a rocket sled. The sled travels at approximately the same speed as the projectile and in the same direction. The projectile is fired horizontally from a weapon and is caught in the box on the rocket sled. Decelerating forces are less than 5% of the accelerating forces. Timing between the projectile and rocket sled is very critical, and the cost of the test is quite high. This test is presently conducted at the Naval Weapons Center, China Lake, California and is used when it is critically important that no damage be inflicted to the projectile (or rocket) upon deceleration.

10.2 Parachute Recovery. Two types of 155-mm howitzer-fired parachute recovery systems have been used at the Sandia Laboratories, Albuquerque, New Mexico. These are specialized techniques which require projectiles designed specifically for the intended application. While not as expensive as the rocket sled technique, costs are high enough to restrict application to cases where deceleration forces must be minimized. The type system selected is dependent on the projectile component under test.

10.2.1 Base Deployment. The projectile with its test components is fired at any elevation. A mechanical time fuze activates a small charge which expels a parachute out of the rear of the projectile. Impact occurs nose first but deceleration impact forces are minimized due to the drag force of the parachute.

10.2.2 Forward Deployment. The projectile containing test components is launched at an elevation of 85 degrees. A nose-up attitude is maintained past apogee, and the nose-mounted parachute is deployed shortly after the projectile begins its base-first descent. Impact occurs base first with deceleration loads much lower than setback loads.

10.3 Long Tube Utilizing Compressed Air. The test projectile is held in place in the chamber by a grooved diaphragm until the air pressure builds up to the proper pressure, at which time the diaphragm shears through and the test item is accelerated down a long, closed barrel. Compression of the air ahead of the projectile gradually slows, stops, and then accelerates the projectile in the opposite direction, oscillating to a stop. The Naval Ordnance Laboratory, White Oak, Md., Picatinny Arsenal, Dover, N. J., and Frankford Arsenal, Philadelphia, Pa. all have systems similar to the one described. This method does have limitations in the size and type of test projectile and in some cases spin imparted to the projectile.

10.4 Water-Rail Deceleration. A weapon fires a projectile down a water trough with four rails constraining the projectile to a straight flight. Projectile momentum is changed to water momentum and dissipated as spray. Test assemblies are placed inside the carrier/projectile, subjected to a high energy shock inside the gun tube, and recovered after a low energy catch in the water. The size and type of test item is limited. At present this system is operated by a private concern at its facility.

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10.5 Bubbling Air Through Water. Low deceleration and impact forces are experienced by a projectile when fired into water with air bubbling through it. The deceleration from a water-air mixture can be varied over a wide range of values by adjusting the amount of air bubbles in the water. This has been determined mathematically and is a proposal only. At present, there are no facilities for this type of system. (See ref. 2, appendix.)

10.6 Recovery After Ricochet. A projectile fired at low elevation may ricochet off the ground and come to rest further downrange. A large open area along the line of fire is required. The angle of ricochet is not always consistent which could cause a large projectile dispersion, making recovery difficult. Velocities have to be kept low so that travel of the projectile after ricochet will not be too great. Yuma Proving Ground has done this type of testing. (See ref. 2, appendix.)

10.7 Styrofoam. A styrofoam recovery medium is suitable only for small arms projectiles (through 20-mm). A typical arrangement consists of 2-foot-thick styrofoam blocks arranged in a line 50 feet long to stop a service-fired 14.5-mm projectile.

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APPENDIX  
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